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Original Article

ENERGY BALANCE OF INDIAN RURAL WOMEN DETERMINED BY THEIR ACTIVITY BASED ENERGY COST: A CROSS-SECTIONAL STUDY

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ABSTRACT

Background: ***Inaccuracy between estimated intakes and energy consumption are commonly reported for marginally malnourished populations in the developing world. In India, this situation is more crucial among rural women who have to endure hard labor inside or outside of their home due to the lack of knowledge and access to energy reduction techniques and lifestyle. Therefore this study has been performed with the objective to investigate the extent of energy expenditure, contributing to energy balance and their correlates.***

Material and Methods: ***This investigation was led among 610 rural women of reproductive age group (15-49 years) in rural Varanasi using face to face interview technique for assessing energy balance. The required sample size was selected by adopting a multi-stage random sampling procedure. 24 hours activity of subjects was recorded by using a pre-tested interview schedule so as to compute energy expenditure and energy balance. The gathered information was analyzed with the help of SPSS software, version 22nd.***

Results: ***Energy balance was negative in 67.4% and positive among 32.6% study subjects. The overall energy expenditure was 1943.05 (±553.24) Kcal/day. The average energy expenditure of subjects from nuclear family (2018.04 ±589.60 Kcal/day) was significantly (p<0.001) more than subjects from joint family (1854.64 Kcal/day ±505.55 Kcal/day) and among illiterate subjects (1997.22 ±573.97 Kcal) was significantly more than those of subjects having educational status as middle (1833.38, ±479.47 Kcal/day) and graduate. Energy expenditure of subjects from the middle (1978.62 ±533.15 kcal/day), lower middle (2020.72 ±553.39 Kcal/day), and lower class was significantly (p<0.001) more than subjects from upper (1603.82 ±87.37 Kcal/day) and upper middle (1739.28 ±469.30 Kcal/day), socio-economic status. There existed a significant association between energy balance of study subjects and their age, educational status, socio-economic status, maximum education in the family and occupation of the head of the family.***

Conclusion: ***Findings of the study have policy and programmes implications to fight with malnutrition associated with the factors causing stress in energy utilization among rural women of reproductive age group.***

KEYWORDS: ***Energy Balance, Energy Expenditure, Reproductive Age & Rural Women***

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INTRODUCTION

The prescribed energy prerequisite of an individual is the level of energy intake (EI) from food that will balance energy expenditure (EE) when the individual maintains his body composition and level of physical activity, consistent with long term good health. The energy balance (EB) i.e. the difference between energy intake and energy expenditure represents the absolute difference between the two.

In most of the researches, discrepancies between measured intakes and estimates of energy expenditure are commonly reported for marginally malnourished populations in the developing world. Exceptionally low dimensions of energy intake, which appears to be contradictory with the proportions of necessary physical activity related with rural farming life, are frequently clarified by energy sparing through a decrease in the energy cost of activities in basal metabolic rate (BMR) (Durnin et al, 1990; Poppitt et al, 1993), a decrease in discretional activities (Edmundson, Sukhatme 1992; Pastore et al, 1993) or a decrease in the energy cost of activities (Shetty, 1984). However, in the real-life situation with marginal but sustained energy stress, the reduction in BMR is believed to be negligible (Ferro-Luzzi, 1990). Although the reduction in physical activity appears to be an easy strategy to combat energy stress, it is not always possible in subsistence farming communities (Bleiberg et al, 1980). In fact, the change in physical activity that occurs is due only to the seasonality in agricultural tasks (Ferro-Luzzi et al, 1994). Thus, observed seasonal variation in body weight or body fat (Branca et al, 1993; Vinoy et al, 2000) in such communities reflects a way of coping with their marginal energy stress (Adams, 1995). With little scope for reduction in activity, the decline in the energy cost of activities is in this way accepted to be the justifiable and attainable method for coping with energy stress at no or a minimum cost (Ferro-Luzzi, 1990). Proof recommends that even among people of comparable age and sex, physical activity is typically the most significant factor causing variations in energy expenditure (Hegsted, 1974). Studies reporting energy expenditure on various activities for Indian adults are scarce (Banerjee et al, 1971) and those available are on women engaged in activities other than farming (Sujatha et al, 2000). Indian rural women are mostly engaged in domestic chores and also contribute generously to farming activities (Rao et al, 2007). Some evidence confirms that while women get a 'disproportionately' small share of household food; they may expend a larger proportion of 'household energy'. A couple of studies (Batliwala, 1982; Jain, Chand, 1979; Khan et al., 1982) proposed that women work longer hours and expend more energy than men. Batliwala (1982) evaluated that women had a deficiency of 100 calories per day on an average if their physical activity in paid and unpaid domestic work were considered altogether, while men had a surplus of 800 calories.

Since there is a dearth of data available in the special context of physical activity and energy balance of Indian rural women, in relation to their health and nutritional status; the **objective** of this study was to examine the situation of energy balance in women of reproductive age group. It further explored the correlates of the situation under reference.

METHODOLOGY

To fulfill the aim of this study following methods were used.

Population and Study Design

A community-based cross-sectional design was adopted in rural areas of Varanasi district, which is often called cultural capital of India. It lies in the eastern part of Uttar Pradesh state. The total population of the district is 3,676,841 of which 56.6 % is rural (census 2011). Computation of required sample size of 576 was based on the assumption that prevalence of chronic energy deficiency (CED) among Indian rural reproductive age group women around 40% and permissible level of error as 10% of the prevalence rate. Thus 610 Women of reproductive age group (15-49 years) were considered for this study. Pregnant and seriously ill women were excluded. The required sample size was selected by adopting multi-stage sampling. Following steps were involved in the selection of study subjects.

- One Commissionary of Uttar Pradesh state (comprising of 7 districts) was selected randomly.
- One district (viz. Varanasi) from the selected commissionary was selected by simple random sampling.

- One block (viz. Chiraigaon) out of 8 community development blocks from rural Varanasi was selected by simple random sampling.
- Five villages out of 84 villages of the selected block were selected by systematic random sampling.
- Every seventh household from the selected villages were selected by systematic random sampling (PPS).
- From each household one study subject was selected.

The study had prior approval of the academic bodies of Banaras Hindu University, Varanasi, India and prior consent was taken from the study subjects for participation in this study.

Measurements

Information regarding energy (dietary) intake and energy expenditure was recorded by using 24 hours of dietary and physical activity recall oral questionnaire method using standard techniques. This served as the basis for estimation of their energy expenditure with the help of activity-based energy cost (Rao et.al, 2007). The influence of various variables on energy balance was examined by generating cross tables. In order to pinpoint correlates of energy balance logistic regression analysis were applied.

Data Analysis

Generated data were analyzed with the help of Microsoft Excel and SPSS software version 22nd. Energy Balance of study subjects was calculated by the difference in energy intake and energy expenditure (kcal/day). In order to identify the absolute contribution of influencing factors χ^2 logistic regression and ANOVA were applied.

RESULTS

As much as 67.4% of study subjects were in negative energy balance (NEB) and 32.6% had positive energy balance (PEB) (Figure:1). The overall EE for study subjects was 1943.05 ±553.24 Kcal/day. Energy expenditure of study subjects according to socio-demographic variables is given in table 1. Age, religion, caste, marital status of subjects, the primary occupation of the subjects, maximum education in the family and main occupation of the head of the family were not significantly ($p>0.05$) associated with an energy expenditure of study subjects. There existed a significant association between energy expenditure of the subjects and their type of family. Post hoc test revealed that the average energy expenditure of subjects from the nuclear family (2018.04 ±589.60 Kcal/day) was significantly more than subjects from joint family (1854.64 ±505.55 Kcal/day). EE of subjects from middle (1978.62 ±533.15 kcal/day), lower middle (2020.72 ±553.39 Kcal/day), and lower class were significantly more than subjects from upper (1603.82 ±87.37 Kcal) and upper middle (1739.28 ±469.30 Kcal/day), socio-economic status (SES) exerted significant ($p<0.001$) influence on energy expenditure of the subjects. Post hoc analysis demonstrated the result of energy expenditure of illiterate subjects (1997.22 Kcal, ±573.97 Kcal) to be significantly more than those of subjects having educational status as the middle (1833.38 Kcal/day, ±479.47 Kcal/day) and graduate (1824.50 ±389.74 Kcal/day).

Table 1: ANOVA for Total Energy Expenditure of Study Subjects

Sl.No.	Variables	N	Mean (SD)	F Value	P Value
1	**Age of the Subjects (in Years)**				
	15-24	219	1942.53 (±533.56)	**1.193**	**0.312**
	25-34	196	1895.78 (±556.45)		
	35-44	151	2008.64 (±588.11)		
	≥45	44	1931.06 (±505.38)		
2	**Religion**				
	Hindu	566	1948.90 (±554.31)	**0.878**	**0.349**
	Muslim	44	1867.75 (±539.72)		
3	**Caste**				
	SC & ST	191	1951.93 (±629.82)	**1.226**	**0.294**
	OBC	285	1967.58 (±549.42)		
	Others	134	1878.20 (±429.66)		
4	**Type of Family**				
	Nuclear	320	2018.04 (±589.60)	**6.428**	**0.002**
	Joint	260	1854.64 (±505.56)		
	Three Generation Family	30	1909.31 (±433.22)		
5	**Marital Status of Subjects**				
	Unmarried	159	1972.78 (±465.24)	**0.310**	**0.733**
	Married	436	1932.45 (±585.31)		
	Widow & Separated	15	1935.81 (±461.68)		
6	**Educational Status of Subjects**				
	Illiterate	206	1997.22 (±573.97)	**1.897**	**0.093**
	Primary	70	1986.51 (±576.30)		
	Middle	90	1833.38 (±479.47)		
	H. School	86	1984.65 (±550.47)		
	Intermediate	93	1940.83 (±635.27)		
	Graduate & above	65	1824.50 (±389.74)		
7	**Primary Occupation of Subjects**				
	Housewife	386	1933.49 (±596.59)	**0.089**	**0.994**
	Domestic Worker	36	1956.32 (±437.74)		
	Agriculture Labor	19	1971.47 (±457.96)		
	Service	11	1911.79 (±406.19)		
	Student	130	1958.08 (±487.15)		
	Skilled Worker	28	1980.87 (±490.23)		
8	**Socio-Economic Status**				
	Upper Class	33	1603.82 (±87.37)	**6.348**	**0.000**
	Upper Middle Class	56	1739.28 (±469.30)		
	Middle Class	100	1978.62 (±533.15)		
	Lower Middle Class	199	2020.72 (±553.39)		
	Lower Class	222	1959.22 (±593.16)		
9	**Maximum Education in the Family**				
	Illiterate	19	1969.60 (±598.53)	**1.682**	**0.123**
	Upto Primary	68	1955.50 (±498.75)		
	Upto Junior High School	82	1972.16 (±556.94)		
	Upto High School	120	2039.81 (±598.10)		
	Upto Intermediate	132	1964.55 (±664.35)		
	Upto Graduation	126	1836.68 (±428.47)		
	Above Graduation	63	1867.06 (±435.47)		
10	**Main Occupation of Head of the Family**				
	Farmer	78	1915.15 (±478.68)	**1.173**	**0.322**
	Labor	228	2000.07 (±625.23)		
	Service	137	1889.12 (±482.35)		
	Business	96	1949.35 (±556.30)		
	Skilled Worker	71	1886.09 (±500.64)		

There existed a significant association between energy balance of study subjects and their age, educational status, SES, maximum education in the family and occupation of the head of the family. Negative energy balance was to the extent of 65.3%, 64.7% 76.8% and 56.8% in the age group of 15-24, 25-34, 35-44 and ≥45 years of age, respectively. This was maximum (73.8%) in illiterate and least (58.5%) in subjects with educational status as graduate and above. As much as 69.4% lower, 81.9% lower middle and 72% middle SES subjects had NEB. In contrary to this NEB was less in subjects belonging upper middle (23.2%) and Upper (27.3%) SES, NEB was maximum (89.5%) in subjects belonging to illiterate family. Occupation of Head of the family can exert significant influence on the energy balance of subjects. This is also supported by the findings of the present study as well. The extent of NEB was maximum (78.2%) in subjects with the occupation of the head of the family as farmer and least (57.3%) in subjects whose head of the family were engaged in business. Religion, caste, type of family, marital status and occupation of subjects were not significantly associated ($p>0.05$) with their energy balance (Table: 2).

Table 2: Correlates of Energy Balance of Study Subjects with their Socio-Demographic Variables (N=610)

Sl. No.	Variables	Energy Balance of Subjects						Test of Significance
		NEB		PEB		Total		
		No.	%	No.	%	No.	%	
1.	**Age of Subjects (In Years)**							
	15-24	144	65.8	75	34.2	219	100	$\chi^2=9.474$ df=3 $p<0.05$
	25-34	126	64.3	70	35.7	196	100	
	35-44	116	76.8	35	23.2	151	100	
	≥45	25	56.8	19	43.2	44	100	
2.	**Religion**							
	Hindu	382	67.5	184	32.5	566	100	$\chi^2=0.046$ df= 1 $p>0.05$
	Muslim	29	65.9	15	34.1	44	100	
3	**Caste**							
	SC & ST	126	66	65	34	191	100	$\chi^2=7.614$ df=2 $p>0.05$
	OBC	206	72.3	79	27.7	285	100	
	Others	79	59	55	41	134	100	
4	**Type of Family**							
	Nuclear	234	73.1	86	26.9	320	100	$\chi^2=10.198$ df=2 $p>0.05$
	Joint	158	60.8	102	39.2	260	100	
	3 Generation Family	19	63.3	11	36.7	30	100	
5	**Marital Status of Subjects**							$\chi^2=1.336$ df=2 $p>0.05$
	Unmarried	113	71.1	46	28.9	159	100	
	Married	288	66.1	148	33.9	436	100	
	Widow & Separated	10	66.7	5	33.3	15	100	
6	**Educational Status of Subjects**							
	Illiterate	152	73.8	54	26.2	206	100	$\chi^2=1.032$ df=10 $p<0.001$
	Primary	46	65.7	24	34.3	70	100	
	Middle	56	62.2	34	37.8	90	100	
	H. School	59	68.6	27	31.4	86	100	
	Inter	60	64.5	33	35.5	93	100	
	Graduate & Above	38	58.5	27	41.5	65	100	
7	**Occupation of Subjects**							
	Housewife	254	65.8	132	34.2	386	100	$\chi^2=7.782$ df=5 $p>0.05$
	Domestic Worker	25	69.4	11	30.6	36	100	
	Agriculture Laborer	14	73.7	5	26.3	19	100	
	Service	7	63.6	4	36.4	11	100	
	Student	90	69.2	40	30.8	130	100	
	Skilled Worker	21	75.0	7	25.0	28	100	
8	**Socio-Economic Class**							

	Lower	154	69.4	68	30.6	222	100	
	Lower Middle	163	81.9	36	18.1	199	100	$\chi 2=93.254$
	Middle	72	72	28	28	100	100	df=4
	Upper Middle	13	23.2	43	76.8	56	100	$p<0.001$
	Upper	9	27.3	24	72.7	33	100	
9	**Maximum Education in the Family**							
	Illiterate	17	89.5	2	10.5	19	100	
	Upto Primary	46	67.6	22	32.4	68	100	
	Upto Junior High School	65	79.3	17	20.7	82	100	$\chi 2=21.092$
	Upto High School	86	71.7	34	28.3	120	100	df=6
	Upto Intermediate	90	68.2	42	31.8	132	100	$p<0.005$
	Upto Graduation	69	54.8	57	45.2	126	100	
	Above Graduation	38	60.3	25	39.7	63	100	
10	**Occupation of Head of the Family**							
	Farmer	61	78.2	17	21.8	78	100.0	
	Laborer	162	66	66	28.9	228	100.0	$\chi 2=13.180$
	Service	83	60.6	54	39.4	137	100.0	df=4
	Business	55	57.3	41	42.7	96	100.0	$p<0.05$
	Skilled worker	50	70.4	21	29.6	71	100.0	

Significant effect of age and educational status obtained in univariate analysis got eliminated in the logistic model**.** Logistic analysis has revealed that taking maximum education in the family graduation as a reference, AOR of NEB was 2.48 (CI 1.08-5.70) for subjects belonging to the illiterate family. When the occupation of the head of the family as the skilled worker was taken as the reference it was observed that AOR for NEB was 2.71 (CI 1.11- 6.62) for subjects whose head of the family were a farmer. The prediction model calculated the overall percentage of correct classification of energy balance among subjects by the logistic model to be 75.2%.

DISCUSSIONS

A normal nutritional status is stated when there is sufficiency of nutrients and balance between energy intake and expenditure. A number of researchers (Kaur, 2002; Walia, 2007) have reported a decline in EE with advancing age. The later study has also indicated that after the middle age women consume grater calories in their daily diets both total as well as in relation to their body weight and also exceed the recommended values. There is evidence that if the everyday diet includes a high amount of dietary fat, affinity to gain weight develops more easily (George et al, 1990; Kendall et al, 1991; Scotellaro et al 1991). It is understandable that low level of EI in the event of excess EE can be compensated by energy sparing mechanism through a decrease in basal metabolic rate (Durnin et al. 1990; Poppitt et al. 1993). There may be instances of decrease in discretional activities or decrease in the energy cost of activities (Edmundson & Sukhatme 1992; Pastore et al, 1993; Shetty, 1984). Reduction in physical activity appears to be an easy strategy to combat energy stress. However in real life situation with marginal but sustained energy stress reduction in BMR is believed to be negligible (Bleiberg et al. 1980; Ferro-Luzzi, 1990). Variation in energy expenditure may occur due to seasonality in agriculture tasks. Since the present study was cross-sectional in nature it cannot capture variations of energy expenditure in different seasons of the year. Seasonal variation in body fat and weight reflects a way of coping with marginal energy stress (Adams, 1995, Branca et al. 1993; Ferro-Luzzi, 1990; Vinoy et al, 2000).

In the present study activity based energy expenditure suggested by Rao et al. (2007) served as the basis for computation of EE. Physical activity causes maximum variation in energy expenditure (Hegsted, 1974). Activity pattern of the study subjects was assessed by 24-hour recall method. There is a paucity of data on EE of various activities and those

who are available needs to be reviewed due to variation in the context of the study and changes in technology used in the agriculture sector and use of household appliances. These processes have considering the reduced energy cost of activities (Banerjee et al. 1971; Sujatha et al. 2000). It is of paramount importance to realize that EB at different levels of intake has different implications. The energy balance is the difference between energy intake and energy expenditure, corresponds to the absolute difference between the two. However, the absolute difference has the limitation that it does not make any consideration of the absolute values of intake and expenditure.

A study conducted on women of reproductive age group in Azamgarh district of eastern Uttar Pradesh (Mishra et al, 2011) revealed more negative energy balance (79.8%) in women of reproductive age group than has been reported by several workers (Batliwala, 1982; Carlsen et al. 2010; Jain, Chand, 1979; Khan et al., 1982). As per the examination of the study, as much as 79.8% study subjects belonged to negative energy balance category and those who came under this category, most (93.0%) of the women belonged to SC/ST group and lowest percentage (65.2%) was found to be in upper caste. Subjects belonging to PEB were 20.2% and this was mostly (34.8%) found in the upper caste category. Numerically it can be said that one-third of upper caste females had energy intake less than 80% of the required level while as high as 80% females of SC/ST belonged to this category. Finally, in the community, around half of the females consumed only that much amount of food which was not sufficient to put them even in the category of energy intake equivalent to 80% of the energy expenditure (Mishra et al. 2011).

In a study by Hazarika et al. (2012) in India, the chances of urban females suffering from under nutrition were, 3.1 and 1.7 times higher in the age group of 15-19 years and 20-34 years respectively, in comparison to women in the age group of 35-49 years whereas in rural context, it was 2 and 1.4 times more respectively.

In another study conducted in Punjab in comparison to 30-35 years of age group, the total daily energy expenditure was observed to decline significantly in 45-50 years age group. Subsequent to representing the expansion in body weight by expressing the daily energy consumption in connection to the body weight of the subjects, a comprehensible gradual decrease in energy consumption with the increase in age was observed significantly. Women in the first two age groups of the investigation spent more calories both in absolute terms as well as in relation to their body weight than what they consume as compared to the age groups of 40-45 and 45 to 50 years. According to Walia, (2007), after the age of 40 years, the females tend to have a positive energy balance which if sustained for a long period of time can lead to further weight gain. A similar tendency has been accounted for by Kaur (2002) in her research on normal sedentary women of Punjab. Higher average daily energy expenditure in terms of both, absolute and body weight; in the first two age groups of rural women with associated NEB, although found in low level in comparison to the sedentary urban female subjects of Kaur (2002), reflects a relatively more active lifestyle of the present group of females. The slum women have to be involved in physical occupations of hard labor for their livelihood daily and in this manner show high energy expenditure over the sedentary women of relating ages.

Walia (2007) experienced an increase in average daily energy intake with an increase in age 30-35 years. Women on an average consumed 2098.6 kcal/day in their daily diet that increased to 2238 kcal/day in the age group of 45-50 years this demonstrated an increase of 6.67%. Administration of ANOVA tests to the daily dietary energy intake data of different groups revealed the existence of significant differences between the various age groups. Further exploration with the Schaeffer post Hoc analysis documented significantly more intake of daily dietary energy by females belonging to the higher age groups in comparison with the lower age groups.

Behavioral adjustments by the individuals made it difficult to establish a precise relationship between CED and mortality. According to a study (Shetty and James 1994), BMI and Sickness followed a 'U' shaped curve, indicating that both lower and higher values are harmful to health. It is possible that lower energy intake by individuals may reduce work hours and increased rest/ leisure hours. Weight gain may be prevented in many parts of the developing country, due to the performance of higher physical activities under conditions of lower food intakes. This may ultimately lead to a vicious cycle of low work productivity and wages, poorer health stock and susceptibility to illness linking it back to poverty. Finally, it can be inferred from this study as well as from a study conducted on rural Nigerian women (Ene-Obong, 2001) that education exerts significant influence on nutritional status and well being of rural women (Rao et al, 2010).

Daily high energy intake is a major factor in the development of obesity in the western world. Numerous specialists have confirmed in their investigations that if regular eating routine incorporates a high amount of dietary fat, affinity to put on weight grows more effectively in subjects (George et al 1990; Kendall et al 1991; Scotellaro et al 1991). However, they further reported that when the intake of carbohydrates and fiber is high, it is easier to, lose body weight. The aftereffects of the study conducted in Punjab, clearly indicated that women particularly after the middle age consume greater calories in their daily diets both in total as well as in relation to their body weight and furthermore surpass the recommended values. The energy expenditure profiles indicated a positive energy balance in this group of women with the advancement of their age (Walia, 2007).

In another study, the mean EI from the food frequency questionnaire was significantly lower than the mean EE ($p<0.01$) and underestimated by 10.6% on average. The same difference between methods was observed for both men and women separately. The absolute mean difference between EI and EE was -1.3 (95% CI, -2.0 to -0.6) MJ/day with 95% confidence limits of agreement (± 1.96 SD) of -6.0 to 3.4 MJ/day (Carlsen et al. 2010).

CONCLUSIONS

In findings of the present study, negative energy balance in women of reproductive age prevailed in two third subjects. The average calorie intake of the subjects was not less than 80 percent of the RDA. Energy expenditure was significantly influenced by the type of family, SES, literacy level; this was more in subjects from the nuclear family, belonging to middle and lower middle SES and illiterate subjects. Higher risk of negative energy balance prevailed in subjects belonging to illiterate family and in having the occupation of the head of the family as a farmer. A well-organized programme for women welfare, belonging to the reproductive age group of rural areas; calls for understanding issues explored in this study.

Therefore it can be suggested that an interventional programme emphasizing on activity-based energy expenditure be evolved, implemented and evaluated for efficacy in terms of improving the nutritional status of women of reproductive age group to strengthen the findings of the present study.

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